A New Herring River Restoration Alternative:

Hydrodynamic Modeling of Tide Heights and Salinities with the Existing Dike Replaced by a Wide Sluice-gate Option, and High Toss Road and Mill Creek Unrestricted,

February 2005

The existing Herring River dike has three six-foot wide culverts, two with clapper valves to allow freshwater discharge, and one with a sluice gate open 24 inches high to provide some tidal exchange and fish passage.

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Under current conditions Wellfleet's Herring River dike is highly restrictive to tidal exchange between Wellfleet Harbor and the river (Figure 1). Previous hydrodynamic simulations of tide restoration options for Herring River (described in Spaulding and Grilli 2001), predicted tide heights and salinities for a range of dike-opening options, but all under the assumption that the Mill Creek flood plain, including a portion of the Chequesset Country Club, would be excluded from the restoration area (Figure 2). These simulations also assumed that the small and restrictive culvert at High Toss Road would remain in place.

Subsequent simulations were performed in 2005, again by Drs. Spaulding and Grilli of the University of Rhode Island for the Coastal America Foundation and the NPS. In contrast with earlier work, these simulations were run with no restriction on tidal flow into Mill Creek and upstream of High Toss Road. However, they showed that, even with the existing Herring River Dike completely open, tidal range in the river would not increase (Figure 3). The restoration of a high tidal range (the difference between the level of low and high tides) is critical to restoring salt marsh functions for plants and animals. Clearly, the existing dike opening was neither designed for nor capable of allowing tidal exchange sufficient to restore the diked estuary.

Therefore, additional simulations were performed with a much wider opening in the dike, fitted with sluice gates to allow incremental opening as at Hatches Harbor (Figures 4 & 5). The modeling first demonstrated that an unrestricted opening 30 meters (about 98 feet) wide would allow practically unrestricted tidal flow. The model was then rerun with this 30-meter-wide opening fitted with sluice gates set at varying heights to simulate the effects of a gradual and incremental tide restoration process (Figure 6).

The results of these simulations, with some examples pictured here (Figure 7), show that the new wide-culvert option produces a tidal regime very much like that of the unaltered marsh just below the Herring River Dike. A typical mean tidal salinity distribution is also illustrated (Figure 8).

The wide-sluice gate option has major ecological and practical advantages over the existing structure (see below).

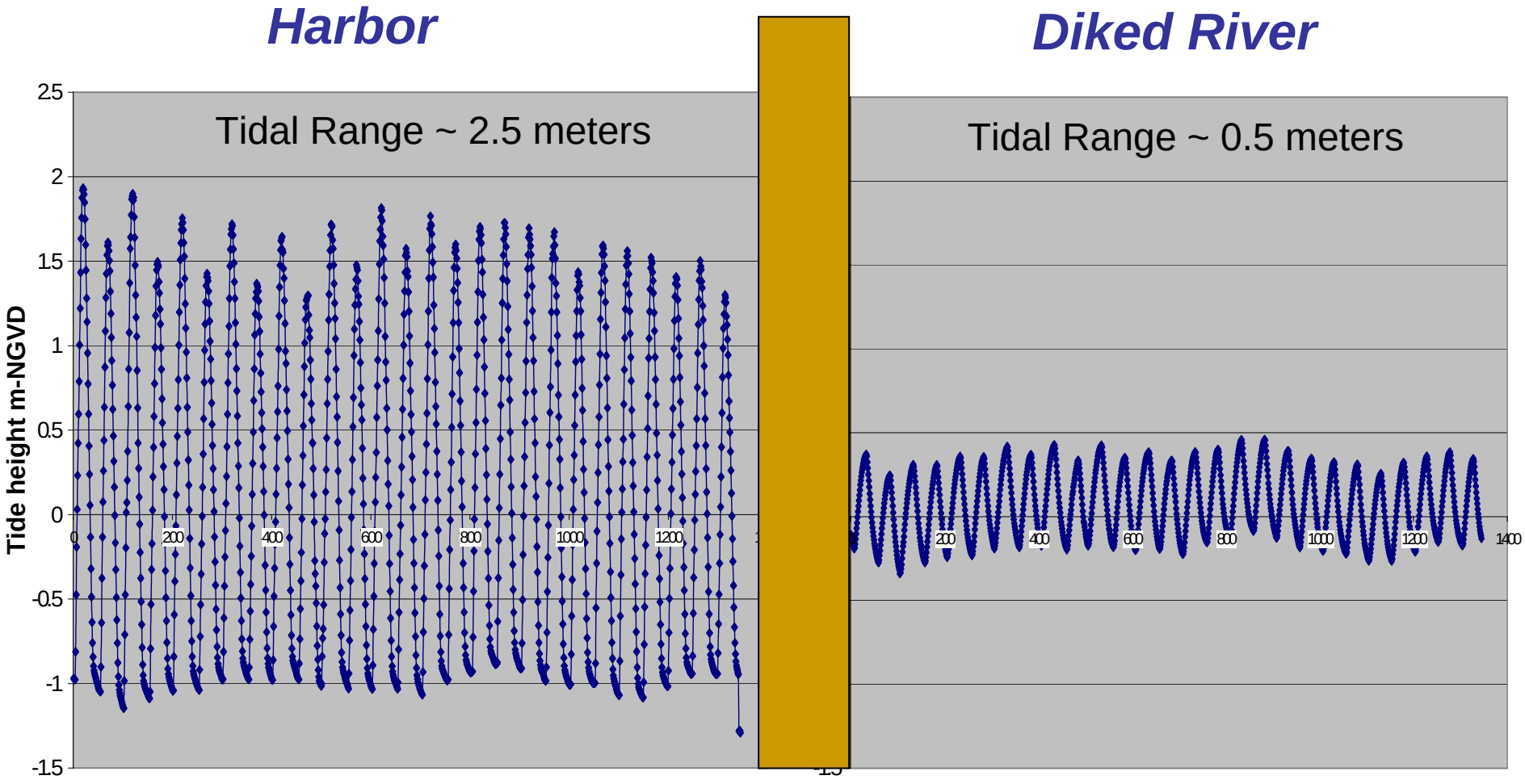

Figure 1. Tides above and below the present Herring River dike. The dike both reduces high-tide height and impedes low-tide drainage, thereby reducing tidal range in the river. Salt marsh productivity is directly related to tidal range. Large differences in water levels above and below the dike cause very rapid flows and impede fish passage.

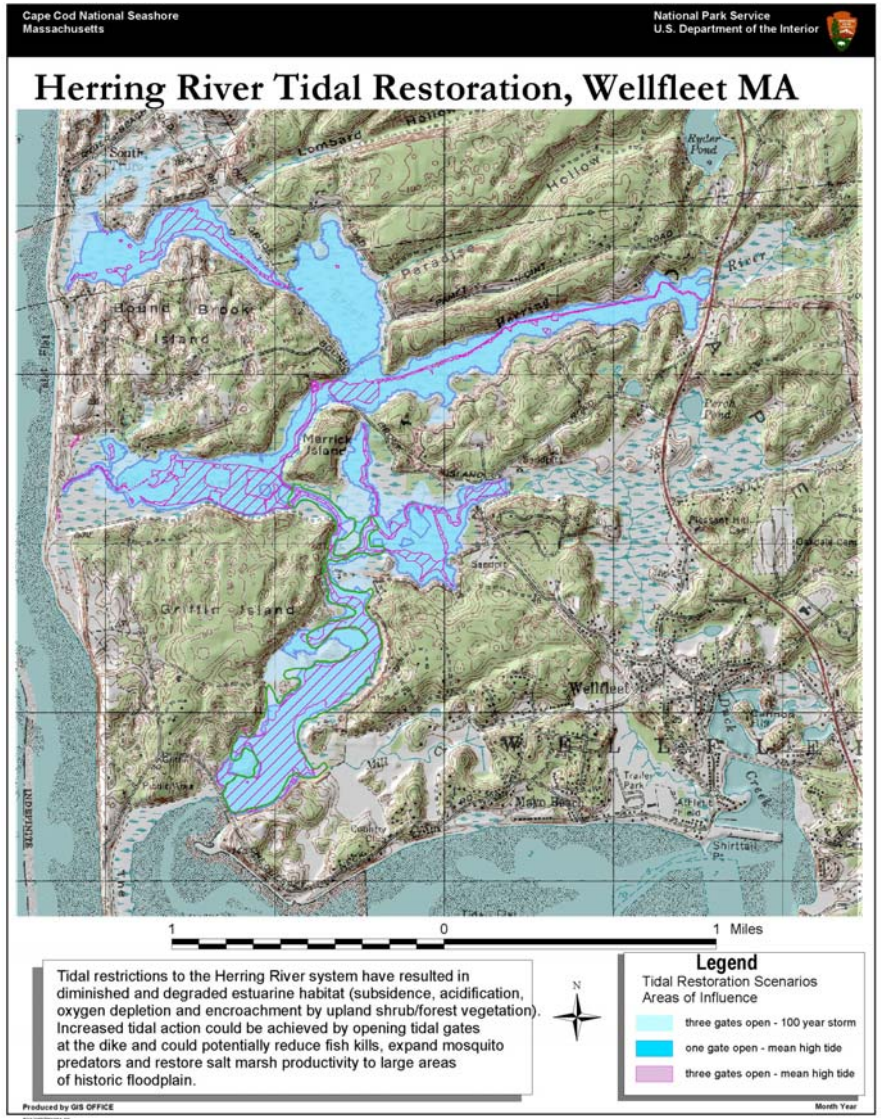

Figure 2. Map of the Herring River flood plain showing extent of tidal flooding with the existing dike culverts fully open, pink cross-hatch (from Spaulding and Grilli hydrodynamic model, 2001).

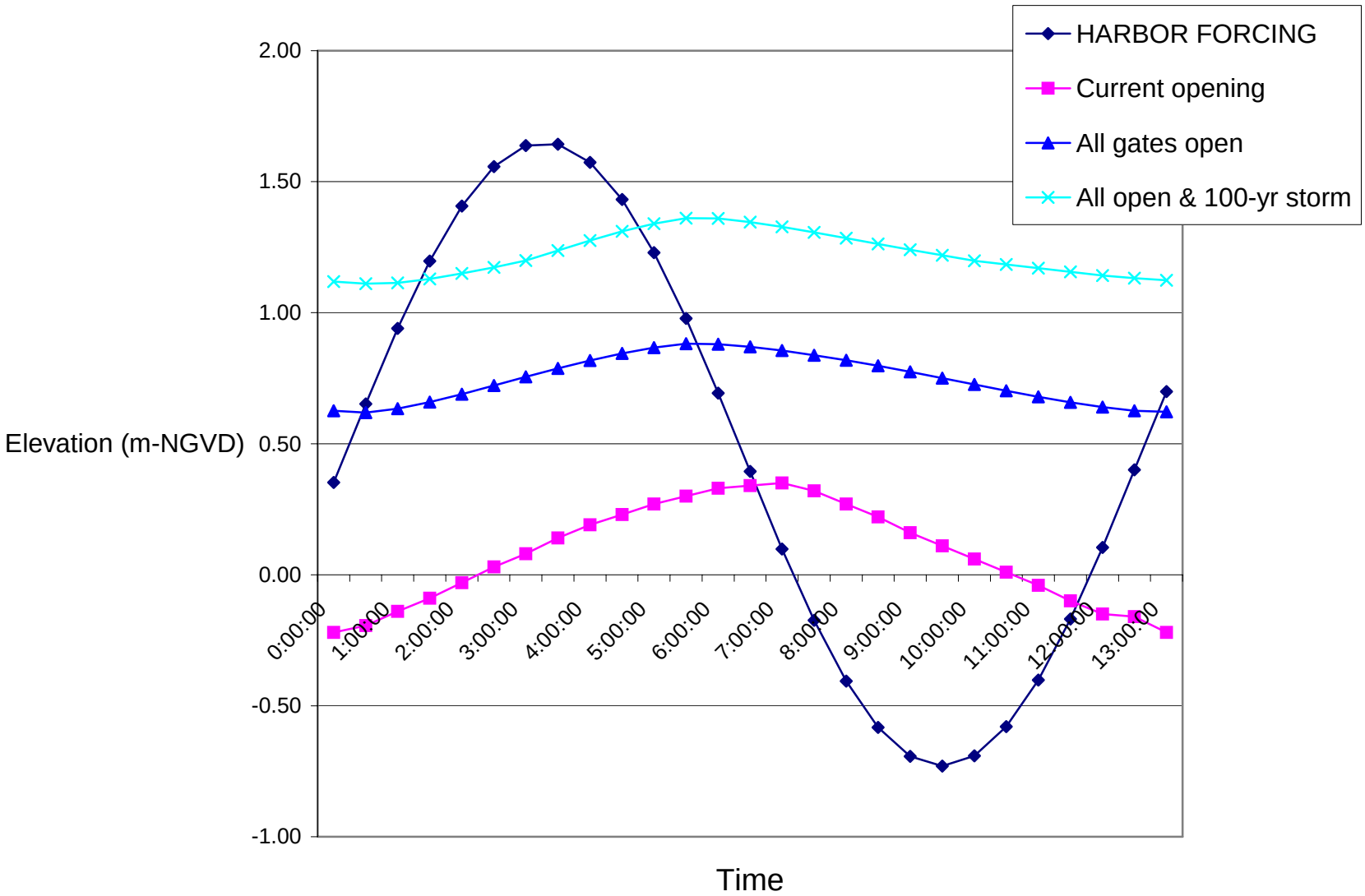

Figure 3. Tide heights over one 13-hour tidal cycle above and below the dike with the current opening and an average tide (pink), and modeled responjse with all gates open and both average (blue) and 100-year storm (light blue) tides. Note that as gates are opened high tides rise, but low tide heights increase even more, so that tidal range, and consequently flushing, actually decreases.

Figure 4. Hatches Harbor culverts, Provincetown

Figure 5. A gated wide-culvert option for Herring River. The image is a composite of the Hatches Harbor culverts superimposed on the Herring River dike.

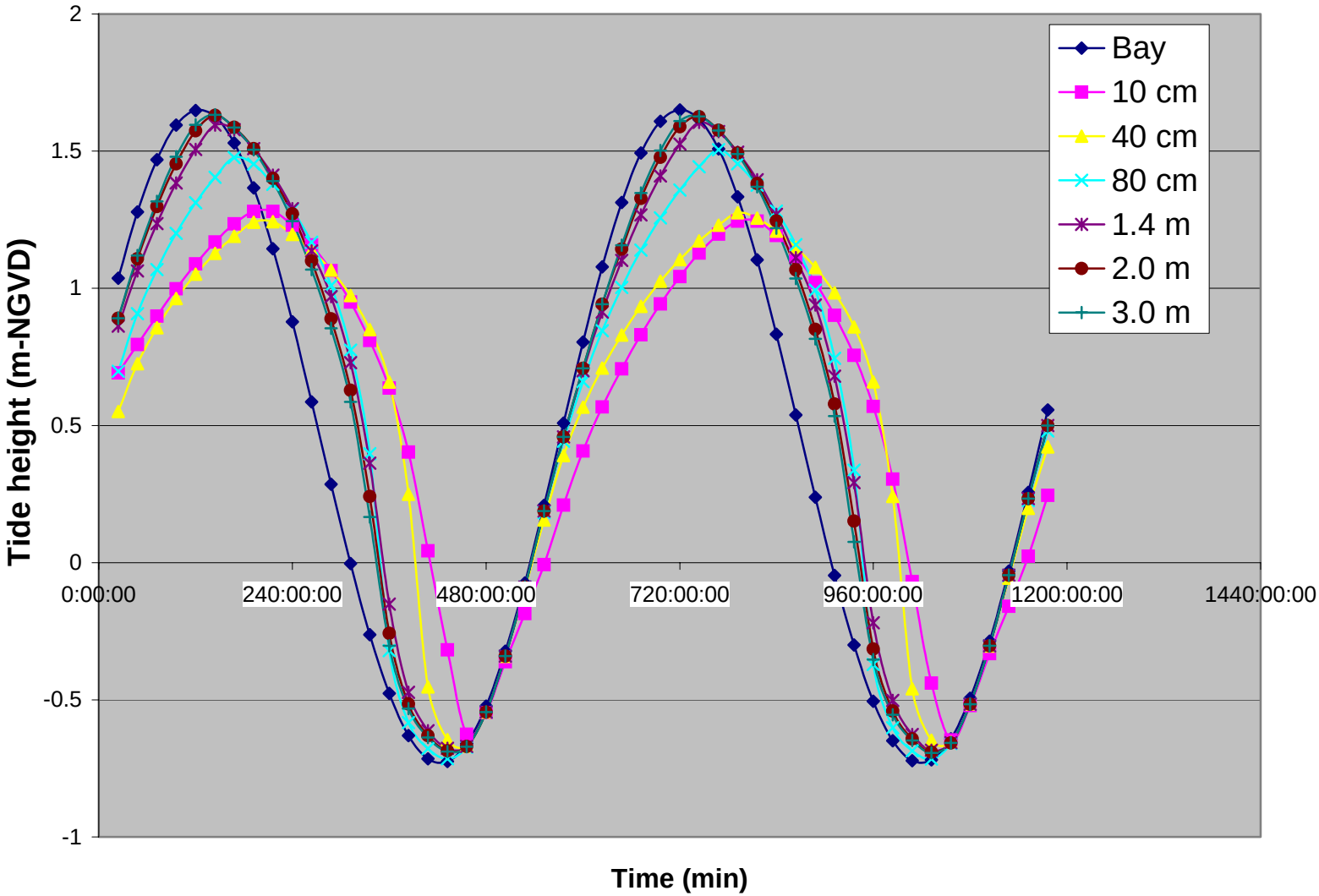

Figure 6. Modeled tidal cycle of Herring River, versus the Bay, with a 30-meter wide adjustable-height opening in the dike. Note large river tidal range (compare to existing conditions, Fig. 3) and excellent low-tide drainage and tidal flushing at even modest gate-opening heights.

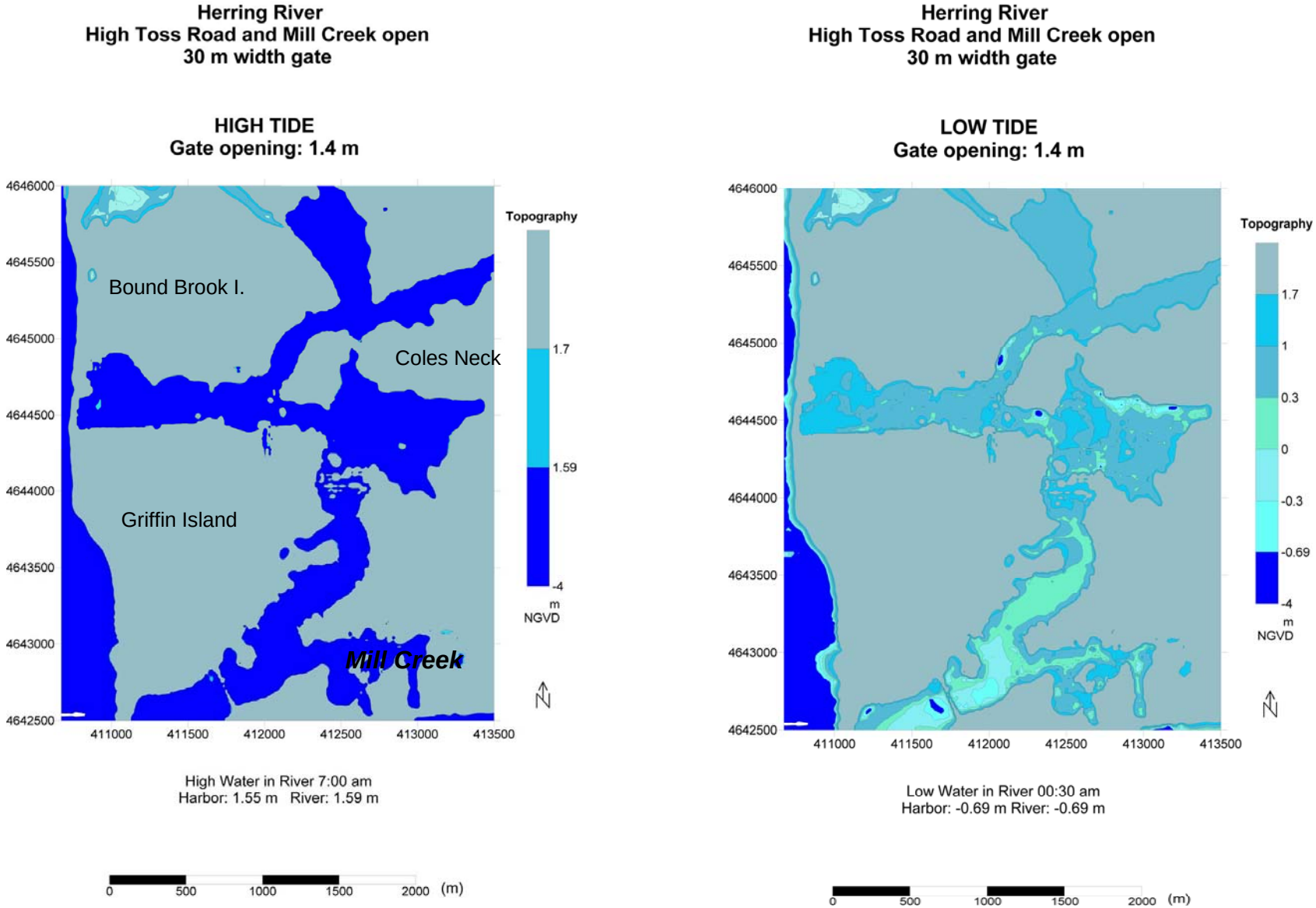

Figure 7. Extent of tidal flooding at high and low tide with the wide-culvert option in the Herring River Dike. This shows an average harbor tide, with 30-meter wide gate open 1.4 m. Note how the system drains almost completely at low tide.

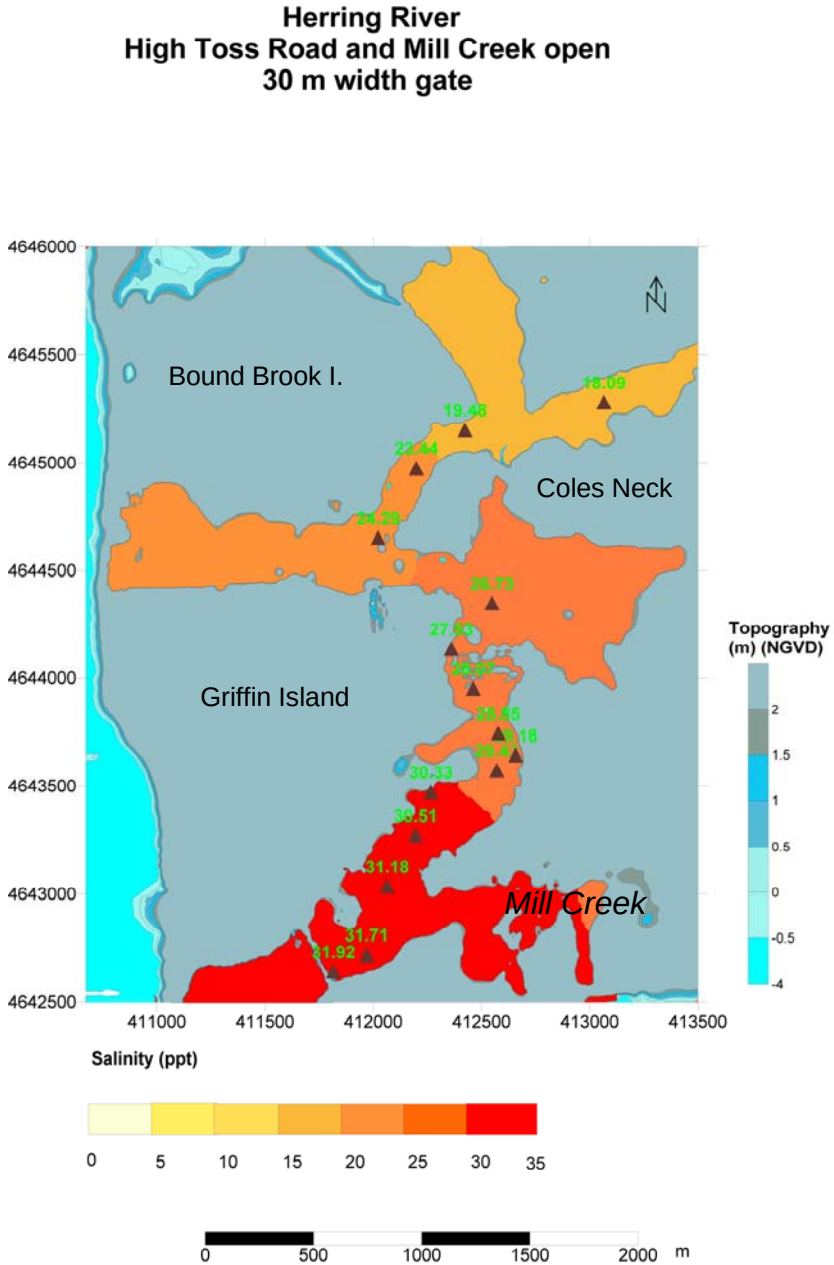

Figure 8. Typical salinity distribution predicted by the model with the 30-meter wide opening, open 1.4 meters high as in Figure 7. For reference, seawater salinity is 32 parts per thousand.

Advantages of Wide-culvert Option:

1. *Incrementally opened to control and adaptively manage gradual restoration.*

2. *Increased tidal range and flushing, and associated ecological benefits, with modest increase in high tide heights, by improved low-tide drainage.*

3. *With lower low tides, decreased mean river water level relative to structures that remain close to the flood plain, e.g. improved drainage of adjacent lands.*

4. *Increased tidal range translating to increased wetland productivity and improved flushing, e.g. of bacteria if present, and improved water quality.*

5. *River tides more synchronous (in phase with) Harbor tides, so current velocities and sediment resuspension decrease.*

6. *Increased low-tide drainage and flushing reduce floodwater mosquito habitat.*

7. *Low, wide culverts filter out storm tides that could affect low-lying structures.* The lower the gates, the greater the dampening of high-tide heights.

8. *Over the very long term, design allows whatever level of tidal restoration is ultimately selected, up to full restoration.*